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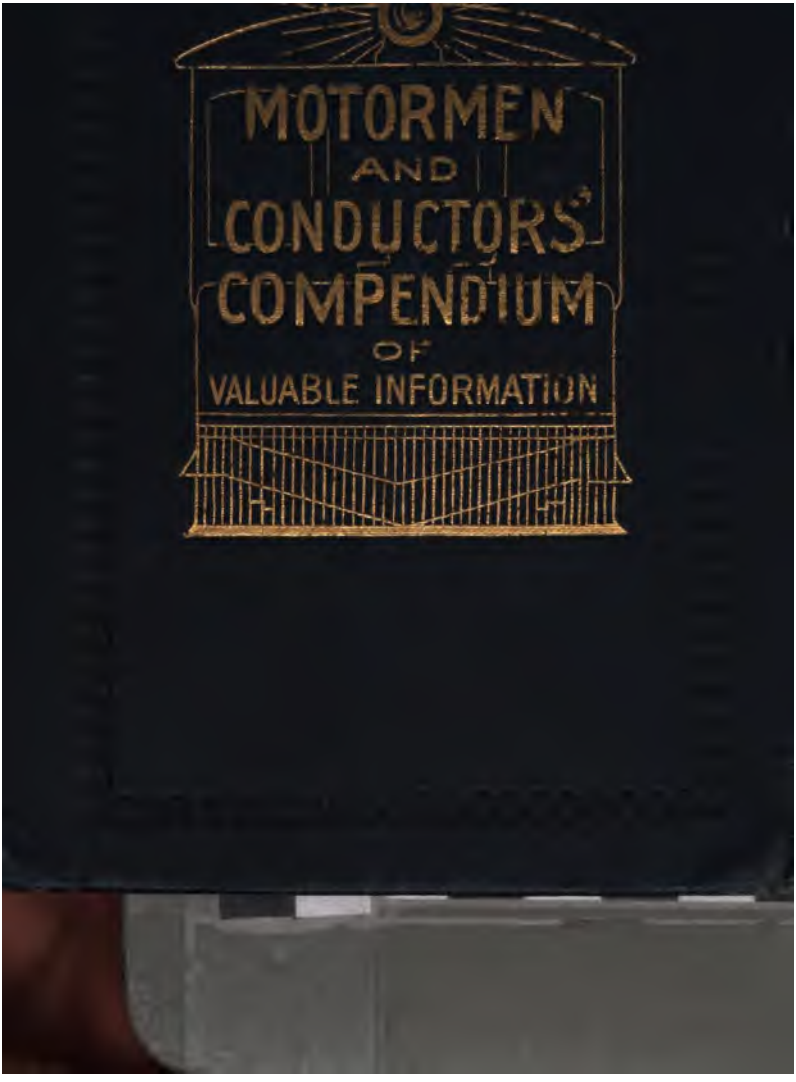
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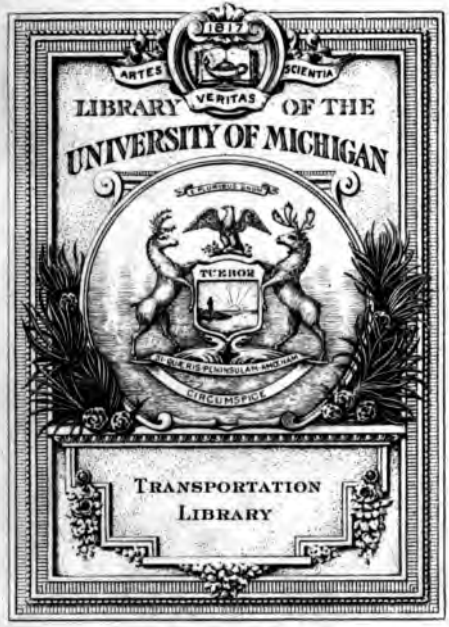
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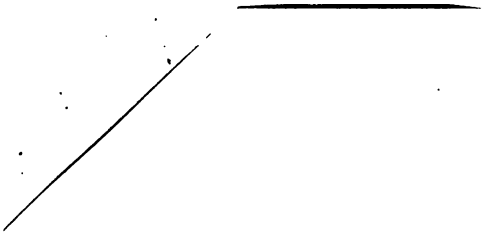

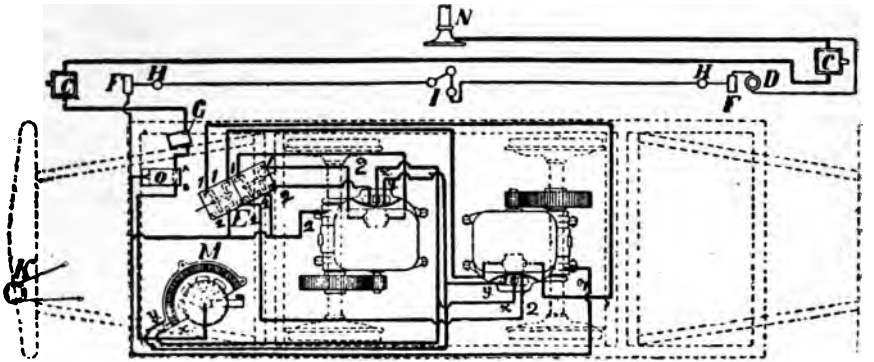

C R. R. Motor Switch.
D 15 Light Branch Switch.
E Reversing Switch.
F 10-35 Light Cut-out Box.
G R. R. Motor Cut-out Box.
H Pilot Lamp.
I Three Lamp Cluster.
O Lightning Arrester.
M Rheostat or Resistance Coils.
N Trolley Stand.
Y End Wire.
X Loop Wire.
1 Brush Wires.
2 Dead Ground Wires.

MOTORMEN

AND

CONDUCTORS' COMPENDIUM

OF

VALUABLE INFORMATION

(Motorman's Guide)

By
J. W. GAYETTY

A Practical Treatise on the Care and Operation of Street Railway Motors, including Car Wiring, Short Circuits and how to locate them; Incandescent Light Circuits; Operation of K Controllers; Series Parallel Controller; Westinghouse Motors; General Electric 800 Railway Motor, and the Proper Way to Cut Out Motors, Etc., Etc.

Special Descriptive Diagrams and Illustrations

CHICAGO:
LAIRD & LEE

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Introduction.

In presenting this pocket edition to the public I will say that it has been the author's intention to confine himself exclusively to points of interest to the Motormen of the country, realizing, as I do, that there is not, nor has there ever been, anything written which would disclose to this class the knowledge they seek.

In order to do this it is my intention to define everything pertaining to street R. R. Motors in the simplest manner, omitting all algebraic and other terms such as have served in all books previously written, to prevent you from comprehending their meaning. And if strict attention is paid to the teachings

and instructions herein contained, you will be able to withstand the most rigid examination from your Superintendent real or anticipated, as well as to make an intelligible report of the defects and the work to be done on your car and motors. It is not generally known, but it is a fact, nevertheless, that all Motormen on all street railways are to be examined by a State Board of Examiners yet to be appointed by the Governor of each State, as to their qualifications and capabilities to hold the positions they are now filling.

It stands to reason that those found wanting will have to go, and those who have devoted a little of their leisure time to profitable study, will succeed them. It is in order, right here, to state that the man of influence is going to have some hard studying and become posted, or step down and out, as the pull cannot hold him. He must possess a thorough knowledge of his business, or those who do will certainly succeed him.

It is indeed necessary to repeat here

that old adage, "a still tongue makes a wise head;" and what is meant by using the saying is, what you learn keep to yourself; or in other words, do not lend your book to anyone, for as the saying goes, "one man prospers by his fellow-man's downfall." So do not assist in your own downfall.

Recognizing the fact that not one Motorman in twenty thoroughly understands his motors, I feel that I am giving them great value for their money, and at the same time furnishing them with the means of holding a position on any line they may be employed on. While serving as foreman in different car houses, the author has been able to gain a great many pointers that will come up on the examination of Motormen and conductors, and having possessed these, together with my knowledge of electricity, I feel perfectly safe in stating that they cannot ask you any question that I have not honestly and correctly answered in this little book. If you wish to learn the value of this

book, go to your electrician, or man in charge of your motors, and ask him for information, and then, and not until then, will you learn the true value of this book. It has always been understood by all electricians or foremen of car houses, that no information of any importance be given to anyone outside of their class, and consequently most men running cars to-day are ignorant of their motors.

Now that I have dissolved partnership with that class of people, I am at liberty to impart to Motormen and conductors how to thoroughly understand and man their machines, regardless of what my brother electricians may deem fit to say or think about me. I have honestly served my time, and think I have a right to suit my own pleasure in regard to what use I make of my experience.

Having been a Motorman myself I know how insignificant a man is and how small he feels when running a car with no knowledge whatever of his motors.

It has been my experience to see hun-

dreds of cars turned in off the road by Motormen who were asked by housemen what the trouble was. Well, of course their answer would be, simply "I don't know."

And they should not be held responsible for what they have had no chance or opportunity to learn.

It will be well for me state here that it is the earnest desire of every company owning and operating electric roads to have each and everyone of their employees thoroughly understand the complete workings of their motors, for it would be a saving of thousands of dollars each year to them.

On the other hand it is the same amount of money in the different electric companies' pockets to keep the men in ignorance.

Now, then, you are aware that neither of the companies will protect you in ignorance, so it behooves you to work out your own salvation, and the sooner

you grasp the opportunity, the better for you and your family.

I propose to write this book just as I have learned it from actual experience and hard work on motors, and it will be more valuable to you than a book written by highly educated electricians where nothing but highly electrical terms and phrases are used.

There are a number of such books now on the market that Motormen have bought at fancy prices and after reading they are just as much in the dark as before they read them. In fact they seldom look at them the second time, for the simple reason that the Motormen of to-day are totally unprepared for such works, and cannot understand them.

It is foreign reading to them and was never intended to give them any information of what they ought to know. Knowing the above statement to be facts, I propose to write this book in plain Motorman's language, starting in from the very beginning the same as if

you had never seen a car, and carry you right along through, explaining in detail every part of a street car motor, and will confine myself to actual information necessary to the Motorman.

A Practical Motorman.

Car Wiring.

It is very necessary that each and every Motorman should thoroughly understand how a car is wired, and then in case one of the connections break, he can readily find it and repair it. You will find in this pocket edition a complete drawing of the wiring of a car with two motors wired in multiple.

By following very closely the explanation here given with your drawing before you, it will be very easy to understand it, and it will enable you to trace your current from the trolley wire through the different parts of your car to the ground.

Commencing at the trolley head, or wheel, it is received from the trolley wire

thence down the trolley pole to trolley stand, there you will find the first connection made connecting your trolley with the car wire. Your current and wire leads from the trolley stand to the front over-head cut-out box, where two connections are made; crossing same, returns along roof of car to rear over-head cut-out box, where also two connections are found; crossing cut-out box, wire runs down corner post of car to the fuse box with two more connections, it runs to the lightning arrester crossing, with two connections.

After leaving the lightning arrester it runs along the flooring of your car to the controller, or resistance coils, which receives it with one connection and dispatches it with another.

Leaving resistance coils it runs direct to your field coils through what is termed the end wire, where a connection is made.

Passing through the field coils it returns out of the same through the field

ground-wire where a connection is made with the fields and field ground-wire.

It next runs direct to the reverse switch; connecting with same it crosses and connects with the positive brush lead, which conducts it to the commutator where a connection is made on to the brush or carbon holder.

It is then received by the armature from the commutator. Passing through the armature it returns through and is received by the negative brush lead and conducted back to the reverse switch with same connections made as when crossing before.

Crossing reverse switch, it is received by the motor ground-wire which runs to and is connected on to the front end of motor casing.

The above is a correct illustration of car wiring and current tracing, and when reading, by frequent reference to the accompanying cut or drawing, can be readily understood.

The high speed or loop wire takes th

same course as the end wire connected to your controller, with all resistance cut out it runs direct to the field coils, side by side with your end wire, passing through field coils, returns through and out field ground wire; there is only one field ground-wire and consequently the fields discharge the current received from both the loop and end wire through the same wire. It must also be borne in mind that the field coils receive current from one wire at a time; when receiving from the end wire the loop is cut out, also when receiving from the loop wire the end wire is cut out.

The current received by the field coils through the loop or high-speed wire returns out the field ground-wire, and runs direct to the reverse switch, crossing same, to positive brush lead, thence to commutator, into armature. Out of armature, through negative brush lead, back to reverse switch, crossing to motor ground-wire to the casing on motor.

Terminal or Field Wires

There are three wires leading into the field-coils, and it is very necessary for a Motorman to know and be able to distinguish one from another, which is very easily done if you will pay strict attention to the following description.

The inside wire on each field coil is the end wire. To be more sure and explicit, we will say the wire nearest the gearing, on the opposite motor, is the end wire. The location of the end wire can be more readily understood after we locate the loop and field ground-wire.

The loop or high-speed wire is the center or middle wire. The outside wire on each machine is the field ground wire, or the wire nearest the ends of the car.

By referring to the car-wiring cut with the above explanation you can post yourself thoroughly, and know positively which wires to disconnect in case one of your motors becomes disabled.

How to Locate Trouble in a Car while Running on the Road

This, perhaps, is the most difficult problem a Motorman is called upon to solve, and one which occurs to him almost daily. It does not matter whether a motor is new or old, there is quite a number of things could happen to it at any moment, and you want to be posted so as to be able to locate and fix it quickly and make time.

If your car, while on the road, should lose the power, and fail to respond to your controller, first ascertain if the trouble is at the power station by trying your light circuit. If your lamps light you know the trouble is in your car; such being the case, you will examine the overhead cutout switches, as some mischievous person may have thrown one of them off. Finding both switches O. K., examine your fuse, as they often melt off. Finding this O. K., next examine your reversing switch by throwing switch both

ways, as quite often cars will throw the reverse on the center while rounding a curve, especially cars equipped with cable controllers. I have seen quite a number of cars laid out on the road from this cause aloe, the Motorman having examined the car thoroughly, and overlooking this particular part. Finding this O. K., it is then necessary for you to run over all connections, as one of them may have broken off. If you find them all intact, you have performed all the duty that is expected of you, for if the trouble is not found by the above inspection, it lies in your motors, and is beyond your reach, consequently you will not be held responsible.

A Motorman cannot be too thorough in his investigations, for he can easily overlook a broken feed wire, which if found after his reporting everything O. K. would place him in an unfavorable light with the electrician or house foreman in charge.

It is very easy for every man to familiarize himself with every connection on or

about his car, as you have an abundance of time while on the road or at the car house. Practice makes perfect, and if you will study a little along with your practice, you will be rewarded for so doing, as a man who thoroughly understands his car and its workings is soon found out and receives more than ordinary attention both from his employer and his fellow men.

The Proper Way to Cut Out Different Motors

There are a great many Motormen who do not know how to intelligently cut a motor out of circuit in case it gets disabled, and this information is intended for those who do not know; who have tried to get it in vain. I have seen cars brought in off the road with every wire disconnected that the Motorman could find about the machine. In such cases the men are only guessing at the result

and consequently are scared half to death for fear they have done something that will incur the displeasure of the electrician in charge.

There are different ways of cutting out a motor. One way is simple and quick: remove the carbons or brushes. But it will be well for me to state that removing the brushes will not be allowed by some electricians, as it is not the safest plan on account of some brush holders coming in too close contact with your commutator. If you can get permission from your electrician in charge to cut out a motor by removing the brushes, it would be easier for you and would exonerate you in case of trouble.

The proper and safest way is to disconnect the end and loop wires from the terminal board, which makes you absolutely safe. This can be done very quickly if you have a small wrench at hand. Remove the small bolts or screws that hold the wires to the field coils or terminal board. After removing bolts or

screws, bend wire back and away from connections, replace bolts and your motor is dead and free from harm. The above method of cutting out a motor only pertains to the general electric system equipped with the rheostat controller, but may be applied to the J controller, providing you are close to the car house and do not have a very great distance to travel, as cutting out a motor equipped with the J controller by removing the brushes, your motor in circuit will not respond until the third speed notch is reached, which gives a heavy jerk to your machinery. All controllers on cars equipped with the general electric system are fast being supplanted by their latest type of controller, known as form K, and it seems to meet a more universal approval than any other yet devised. The controller known as form K can be used with a single equipped motor if desired, but it has been designed for use where double motor equipments are used. At the base of

Points about Motors that should be Examined Often

It is much cheaper to prevent accidents than to repair damages. The liability to accidents may be reduced and the profits of the road correspondingly increased by careful inspection of the apparatus at regular intervals, and this should be insisted upon. The saving in repairs will more than equal the cost of the inspection. A Motorman should, on arriving at the end of the road, examine certain parts of his car without fail. To do this correctly, and feel safe when starting on your return trip that everything is in perfect working order, you will first examine your armatured bearings and see that the compound lubricating cups are filled, or enough compound in them to insure their safe running, for it is often the case that armature bearings become hot and melt the compound, which will soon wind you up in a disabled condition,

whereas timely inspection will prevent this trouble.

The next part to be examined is your carbons or brushes. These very often become broken or cracked, which will cause them to arc, and if they are run in that condition for any length of time will cause your commutator to become so hot that it will short circuit, or may ground your brush holder. In either case your motor will have to be cut out of circuit.

Brushes should make good contact with the commutator. Reach down and take out each brush in order to ascertain whether it moves freely in the brush holder. They should not bind, as this might cause poor contact. In putting brushes back, get the same brush in the same holder and have the same side up. They will make better contact if put back exactly in the same position as they were found. Notice the temperature of the field coils and armature. A loose or broken connection might interfere with the proper distribution of current between

the two motors. Do not allow the fields or armature on one motor to become warmer than the other motor, for in such case it is doing more than its share of the work. If you cannot remedy the trouble on the road report to car inspector.

The next part to be examined is your gearings. See that they are not running dry. Examine your wheel boxes, and if you find any of them running hot, lubricate them with oil. Next see that your brakes are perfect and that all shoes make good contact with the wheels. Next see that your trolley wheel is true with the trolley wire, and keep the wheel well oiled. The life of a trolley wheel will depend upon the quality of the metal of which it is made and upon the number of miles it travels. New wheels should be put in as soon as the wear of the old ones is sufficient to cause them to make a rattling noise when running, and to flash badly when passing the trolley supports. Wheels should be oiled every night or morning, and the Motorman should oil

them during the day if found necessary. The more frequently they are oiled the longer they will last.

The tension of the springs in the base of the trolley should be sufficient to keep the trolley wheel firmly pressed against the wire at any speed which the car may reach. If there is a flashing between the wheel and wire when the car is running fast, this is caused by the springs being too weak, and they should be tightened. It has been my experience to see trolley wheels become hot, wear off, and drop to the ground, which causes any amount of trouble and annoyance; for in such case the conductor is compelled to mount the roof of the car and hold the trolley pole against the wire until the car house is reached. By timely and frequent inspection this trouble can very often be avoided.

Motormen having examined their cars as above directed will merit the approval of their superintendent, and have honestly discharged the duties of a first-class Motorman.

Short Circuits—What a Short Circuit Means—How to Locate it.

Perhaps there is no other electrical term so much used as the term short circuit There are a great many Motormen who have heard the term, but have never had it explained satisfactorily. As a consequence they call every little trouble that comes along a "short circuit." For example, during my employment on one of the most popular electric railways on the Pacific coast, of which I was foreman, I was called out on the road one night by one of the oldest Motormen. On arriving at his car, I asked the usual questions as to what was the trouble. His answer was. "I think there is a short circuit in one of my motors." I examined the motor and found the feed wire which runs to the controller, burned off. As a matter of fact, his car was dead, and as he didn't know what else to say in reply to my question, he gave it as his opinion that his car was "short circuited."

Now, one would not think that a man who had run a motor for three years, would be so ignorant of his machine as that, but nevertheless it is a fact.

Now, there are different ways in which a motor can be "short circuited;" but the term means that the current has been thrown out of its regular channel at some point before reaching its destination. For example, some of the lead wires come in contact with another wire, and the insulation becomes worn off, causing a "short circuit," and causing your motor to jump and jerk. It is always very easy to locate it, as it will cause an "arc" when the current is applied. Or you may have a short circuit in your armature, which will always show up in the same way.

You can most always find it by having your conductor apply a little current while you raise the trap-door and watch your motor.

Such short circuits are generally caused by the insulation being knocked off of one or more of the armature coils at the

point where the wire is bent over the end of the armature core, as it comes in very close contact with the motor frame or case during its rotation, and once it is bare, it takes but a short time to burn out a coil, and sometimes more, which incurs quite an expense to your company to repair it. You should use every effort in your power to prevent it, by releasing your current as soon as a jerk or jump is felt. Do not proceed until you have found the cause of it.

Again, if you should run through a pool of water deep enough to come up into your motor case, it will most invariably "short circuit" your motors by making a contact clear around your commutator, which is supposed to be insulated, one bar from another. So, when you come to a pool of water on your track, always give your car speed enough to carry it through the water by gravity, or release your current before striking the water. Also open your overhead cut-out box thus preventing the current from

contact with the water, and you are usually carried over in safety.

There are a great many other things which might be mentioned on this subject, but as space is limited, I think there has been enough said to teach you the difference between a short circuit and a feed wire being burned off.

It comes in line, however, while treating on "short circuits," to call your attention to the trouble caused by your current becoming grounded, which acts in many cases much the same as a short circuit. Ground circuits are even more severe and effectual in causing your car to come to a sudden stop, or blowing the circuit-breaker at the power station, than a short circuit, for if any of your feed wires become bare of insulation, and should come in direct contact with any portion of the trucks, you will experience quite a sudden jar in your speed, which will lead you to think that you have run up against a brick wall, or something of that sort, and at the same time generally

knocks out a circuit-breaker at the power station, and blows the fuse in your car.

In the majority of cases it is not a frequent occurrence, but nevertheless it occurs occasionally that your commutator becomes grounded onto the armature shaft. In such cases the motor thus affected will refuse to work. Sometimes it will cause a flash or "arc," but in most cases it will just jump and jerk, and you will see smoke arising from your motor casing.

Should you have a car that is equipped with a single motor, in most cases it will not move when the current is applied, but stand still, and if you should allow the current to remain turned on for a minute or so, you will be able to smell that something is burning. But in such cases, never try to run your car until you first cut out your motor that is grounded.

Remember, as I have already explained to you, that while a short circuit is, in some ways, very much like a grounded circuit, and often causes very similar

effects, still they are two separate and distinct interferences, and should be handled with great care, as in either case you are liable to damage your motor seriously if you fail to cut out the disabled one before proceeding on your trip.

Then there is burning out of field coils, which is quite a frequent occurrence on roads where there are heavy grades, or where high speed motors are used. This is caused, principally, by an over-taxation of the fields, which will cause them to become overheated, and this unnatural heat will, in time, cause the insulation on the field wires to become charred, which finally allows the current to jump across from one wire to another, thus causing a short circuit in the field, which will burn it out in short order.

Now if your motor should show any of the above mentioned disorders, and you are not able to locate it at once, a very quick and reliable way to locate it is by cutting out one of the motors—that is if you have a car equipped with two. After

you have cut one out, try it by applying the current, and if you find that the one you have in circuit refuses to run, or jerks when the current is applied, then it is reasonable to believe that the trouble lies in that motor, and that the other one is all right. Cut out the disabled motor, and after cutting the other one in you may proceed to the car house.

But I would not advise you to run any further than is necessary without first reporting the trouble at headquarters, as you are liable to damage the other motor by so doing, as you are now making one motor do the work that is intended for both motors to do.

But if you should try both of your motors by cutting them out as described above, and find that your car still jerks, then it is reasonable to believe that your trouble is caused by a short circuit or ground in some of your wires. But you can usually determine as to that by the way she acts.

Information on Incandescent Light Circuits

It may be of some value to you to know how to prevent yourself from being left in the dark in case your light circuit gives out on you during your run, which is a very common occurrence.

Every man who has ever worked on an electric road for any length of time, has either had his lights go out in his own car, or has seen some other car going along in total darkness. As we all know, it is very dangerous to run a car at night without a headlight, and it is also against the laws of most cities to do so. Therefore it behooves you to educate yourself on this branch of street railroading sufficiently to be able to cope successfully with any little trouble which may occur to you while running a car. By so doing you will avoid being looked upon with disgust by your foreman or electrician in charge, as it is really disgusting to a house-man

to be called away from his work to go out on the road to fix a light circuit for a man who has probably run three or four miles without any light, and on investigating it finds that possibly the only trouble is a lamp burned out.

All cars are equipped with a three-way switch. Should your lights go out on you, begin your investigation by trying your switch both ways. If your lights still refuse to work, then investigate the lamps on the inside of your car, for if it is one on either end of your car, or more properly speaking, if it is one of the hood lamps that is broken, they will light up when you throw your switch the opposite way from what it was when they went out.

After trying your switch both ways and they still refuse to light, then take each lamp from its socket, and if you have no other light to see by, light a match and hold the lamp up between you and the light and you can see whether or not the carbon filament is burned off. Try each

one thus until you have found the one burned out—that, is providing the trouble is caused by a burned out lamp. Should you find one burned out, replace it with a new one if you have one with you. But if you have not do not give up and run in the dark. If your car is wired so as to cut out the front hood lamp of your car, then take out that lamp and put it in place of the burned out one, and when you get to the end of the line change the hood lamp from the front end of your car to the rear end, and thus you can run until turning in time without bothering the men at the car house for a lamp. But should your car be wired in such a way that all your lamps are burning at the same time, (except of course you always have a spare lamp in your headlight—that is if you use electric headlights) but that is too unhandy to change at each end, so take the lamp that has been burned out, break the glass globe and take the two small wires which lead through the butt of the lamp and twist

them together, and then you have what is called a plug. Replace it in the socket where you took the burned out lamp from and turn on your switch, which will give you a much brighter light than you had before, as you now have only four lamps burning on your circuit, and of course your lamps burn at a higher voltage.

Now remember I only recommend this to be done in case of emergency, and you should always send word to the car house for them to send you a lamp as soon as possible, or get one from a passing car, as you are liable to burn all your lamps out by burning them at so high a voltage, if you do not replace the burned out one in a reasonable length of time.

But I consider that it would be even more reasonable, and meet with a more universal approval, even should you burn out all of your lamps, than to undertake to run in the dark without a light, and thereby cause the death of some human being, or even smash a wagon.

Here is another little point that may become useful to you in locating trouble in light circuits. After you have examined all of your lamps and have failed to find any of them that show anything wrong, then examine your light circuit switch, as one of the contact plates may become twisted or bent out of place.

If you find such to be the case, pull down your trolley and take your screw-driver or your pliers, and straighten it out so as to make it come in contact with the revolving portion of the switch, then all is O. K. But if you find your contact O. K., then examine the wires leading into the switch, and see that none of them are broken or burned off.

Next go on top of the car and see that the connection at the trolley base is not broken off. Then follow the wires along the roof of car, as in some cases the trolley will jump off while running at a high rate of speed, and strike a span wire and rebound to the roof of the car, the flanges of the trolley wheel strike one of the

small wires and cut it so as to cause it to burn off after a little. If, after all this, you fail to find anything wrong, (of course always ascertaining that the fuse is not gone,) then you should return to the lamps, as you are most sure you will find the trouble there.

Often a lamp will become useless and refuse to illuminate, and still the carbon or wire in it will look all right. An incandescent lamp must be air-tight or it is no good; and sometimes a lamp that is not perfect in construction will work all right for a time and then all at once will become useless, caused by a small leak somewhere around the butt where the globe is fastened to it. You can locate a lamp that is disabled in this way by taking a lamp out of the socket and take your screwdriver and make a connection in the socket by placing your screwdriver so as to touch both sides of the socket at once. Any kind of metal will do if you have no screwdriver. When you come to the affected lamp and remove it and

make the contact in socket, as above described, the rest of your lamps will light up. Then you can fix the disabled lamp as described above.

By following up these instructions you will seldom be compelled to call for help in case of trouble with your lights, nor will you have to run your car without lights.

An incandescent light circuit is a very simple thing, and you should learn enough about it to be able to care for your lamps, as there is seldom anything seriously wrong with them.

Electric Motor Force, or How Armature Rotation is Obtained, etc.

During my experience as foreman of different electric car houses, I have had the question asked me hundreds of times by Motormen, as to how the rotation of an armature was caused. It is a question that is frequently asked by men who are ambitious to learn, and it is a question you seldom can secure an answer to. And while I do not consider myself competent to give you a very thorough explanation of it, still I will endeavor to give you an idea sufficiently plain to enable you to understand how it is accomplished.

All magnet bars have what is called a north and a south pole, or, more plainly

speaking, a positive and a negative end. One end is the positive, the other the negative.

If you take two straight magnet bars and place them on a stand with the bearings exactly in the center, so that they will swing on this pivoted stand, then place them as close together as you can, so as to allow them to pass each other without striking; then place them at right angles to each other, give them a little start and you will find that they will continue to revolve, as the north pole of one will draw the south pole of the other, and when the two opposite ends come together, the speed of the bars (together with their weight), will carry them on past each other, and then the two opposite ends are acted upon in the same manner, and in that way motion is kept up.

When a heavy current of electricity passed from the trolley wire through the coils of insulated wire which surround these magnet bars, to the ground, the

attractive power of the magnet bars is greatly increased.

I give this illustration to start with because it is so simple; and still it may assist you to comprehend the principle of armature rotation, as the armature rotation is also procured principally from magnetism, and all magnetism is on the same principle, although it may be brought about in entirely different forms.

In a motor of the single reduction type there is but one field coil. This field coil, (which is the magnet coil), is placed around what is termed the pole piece. This pole piece is placed on the inside of the motor case, and is as near the armature as will permit its rotation without causing friction. The current passing through this coil which is wound around the pole piece converts the pole piece into a very powerful magnet. The current passing through the armature also causes it to become magnetized, and the positive side of the armature is attracted or drawn to the pole piece. I say the

positive side of the armature because one of the brushes is the positive and the other the negative, all the time, and consequently the corresponding side of the armature is the same.

Now, I have given you an illustration of how the negative side or end will attract the positive end of a bar, and the same rule will apply to the rotation of an armature; and the power of a motor is obtained, to a certain extent, by the field magnet having the advantage over the armature, by having a leverage on the pinion which is connected to the ends of the armature shaft, which works on the large gear wheel on the axle. This leverage can be ascertained by measuring the circumference of the pinion and the circumference of the armature, as the difference in size is the amount of leverage which the magnetism of the field coils and the armature combined has over the pinion; and then another reduction in the draft is made in the difference between the size of the gearing. Without the ad-

vantage of this leverage, the electric motor force would be insufficient to propel the cars.

This illustration has been given with a view to make it as plain to you as possible how electric motor force is obtained. Realizing, as I do, that heretofore any explanation pertaining to this subject has always been kept beyond your reach, I have thought it best to make it as plain and simple as possible, that men with a limited amount of comprehending ability may be able to grasp the idea.

How to Increase the Speed of a Car by Changing two Connections.

It is the ambition of every Motorman to understand thoroughly every little detail in connection with his car, and while it is my intention to impart to them in full everything practical and possible it will be better for them not to practice the following, as I am only giving this as information, and "where ignorance is bliss, 'tis folly to be wise." As I have hinted before, what you learn keep to yourself, as in most cases proffered information creates a very disagreeable odor.

I feel as though my readers ought to be lenient with me, and not practice anything that I impart to them that is intended

only for information, or that which is calculated to educate them in their line of work.

Motormen understand that the speed of a motor is gauged by the winding in the armature and the size of the gearings. While this is true, there is still another and simple way of increasing the speed of your car by disconnecting your ground and end wire from your terminal board, or more plainly speaking, from the field coils, and cross them and connect again. That is, connect your end wire in the ground wire place, and the ground wire in the end wire place. Remember that the end and ground wires are the outside wires, the middle one being the loop. This being done correctly will increase the speed.

General Information on Westinghouse Motors.

As there are a vast number of these popular machines in use in the United States, I feel that this little book would not be complete without treating upon a few of the most important points; and if you practice the following instructions, you will be able to handle a single reduction Westinghouse motor with perfect safety. The Westinghouse electrical equipments for a car consist of the motors, controlling stands or platform switches, two overhead cut-out switches, diverters, motor cut-out, lightning arrester, fuse block, trolley, lamp circuit and wire cables. Motormen and conductors should be thoroughly familiar with the equipments, so as to be able to suc-

cessfully cope with any trouble that may arise while on the road. There are five points or notches to the controller, each of which gives a corresponding speed. It is not necessary to look at the switch when operating it, for the notches are determined by feeling only. On the first notch the four sections of the diverter, the field coils and the armature are all in series. The succeeding notches cut out the diverter sections in their order as numbered, and the fifth notch leaves only the field coils and the armature in the circuit, and gives the highest speed. The upper and lower bearings of the cylinder and the small wheel at the upper end should be oiled occasionally. Use very little oil, and don't allow it to run down on the cylinder. The cylinder contacts, or rings, should be rubbed off and very slightly moistened with grease to keep them from becoming dry and cutting. The Westinghouse controllers are constructed and designed to give the car a forward motion when the handle is moved

from "off," in the same manner as the hands of a watch go; and if they do not do so, it is because they are connected up wrong. Moving the controller in the opposite direction reverses the car. In cutting off the current, be very careful not to throw the handle beyond "off" position, as this would reverse the motors. The handle of the controller should always be at "off" position when the car is standing still, even if the trolley is not on the wire. When one switch is in use, the other one should be at "off." *Don't try any experiment to see what would happen if both switches were used at the same time.* Before placing trolley on the wire, always examine both switches and see that they are at "off" position. Always leave switches in this position and remove handle when leaving your car. If at any time the controller should not work freely, pull down trolley and remove cover of controller. An inspection will probably show the trouble due to the want of oil, roughness of contacts, or something of

that kind. To start the car forward, throw the handle to the left from "off" to the first notch. Allowing the car to start before moving to second notch, make a pause and then move to third, and so on. Do not move suddenly from "off" to second notch. To run backward observe the same rules, but move handle from "off" to the right. Be careful to throw handle to first notch with the first move. Do not merely move it far enough to make contact, as it will burn your cylinder contacts and make your controller work hard. *Never reverse your motors when the car is running forward*, except in cases of extreme necessity, such as avoiding a collision, or to save life. If there is not time to stop your car with your brakes, reverse to the first or second notch, and keep the handle there until your car begins to move backwards. Don't move it beyond the second notch, for then the wheels might spin around backwards, and your car would not stop as quickly as if they kept revolving in a forward direction.

Reversing is a severe strain on the motors, and should not be resorted to except when absolutely necessary. When switching on current, never jump notches. For instance, do not throw the handle from the first notch to the third, without making a pause at the second, but when switching the current off, throw the handle quickly and with a single motion to "off" position. Don't go beyond this point, however. When going up grade, it is advisable to work at the fifth notch most of the time, as this is the most economical position; and besides, the diverter coils are not designed to be used continuously when the car is heavily loaded, although they will stand it with safety for a considerable time. Go through all curves slowly, using first or second notch. It is better not to stop on very heavy grades or in curves, if it can be avoided. Run slowly through flooded places in the track, and when examining motors, never allow water to drip from your clothing or hat upon the motor. And always re-

member that any electrical trouble can be quickly stopped by pulling the trolley down or by throwing overhead switch. The Westinghouse company have a very simple and easy device for cutting a motor out of circuit. They recognized the fact that the old style of disconnecting wires sometimes confuses Motormen, and have equipped their motors with a cut-out device, which is located inside the car, under the seats, about the middle of the car, a small trap-door being cut in the panel of the seat to permit it to be easily reached. You will find two plugs, pulling out either of which will cut out the motor on the respective sides. That is, pull out the plug nearest the motor that is to be cut out, and your motor is dead.

Westinghouse Fuse Block.

A fuse is placed on the car as a protection to the motors. This fuse is connected into the wire running to the trolley, and is situated in any convenient position on the car. The fuse is not intended to melt or blow with ordinary, or even heavy loads, but is inserted as a precaution in case any of the wires of the car should become grounded or crossed. The capacity of this fuse should be determined usually by the conditions of the road. Extra fuses should be carried on the car in a convenient place, and also a screwdriver, if the latter is required to replace a fuse. Before putting in a new fuse, pull trolley down from wire. With a single motor equipment use a 50 ampere fuse; with double equipments use a 75 ampere fuse. Always pull trolley down when working at the switches, lamp circuit, lightning arrester or fuse block, as you are absolutely safe if you take this precaution.

The Westinghouse Lightning Arrester.

Being entirely automatic in its action, it requires no adjustment after each discharge. It should be examined, however, after each storm as a matter of precaution. By removing triangular plate which closes the front of the arrester, the whole interior may be inspected. The swinging arms must pass freely through the holes into the air chamber, and the carbon tips should touch the carbon blocks, and when pressed in, should move them one-sixteenth of an inch before the flange strikes the marble. The air space between the toothed carbons should not be more than one-sixteenth of an inch. The screws should be firmly set, especially those holding the plate on the window in the air chamber.

Westinghouse Lamp Circuit.

The lamp, or lighting circuit of the car usually consists of five 100 volt lamps connected in series. Where oil head lights are used, three lamps are in a group in the middle of the car, and one on each platform. In this case a small double break switch is provided for cutting the current off from the lights. Where electric head lights are used, each platform lamp is connected in multiple with a head light connecting block; and a two-way switch inside of the car makes it possible to throw either the platform lamp or the head light into the circuit. The lamps may sometimes refuse to light. This will probably be found to be due to one of the following causes: a broken or burned

out lamp, poor contact between one of the lamps and its socket, poor contact in the switch, a loose or broken wire, or a blown fuse. The remedies being, in the first case, to replace the defective lamp with a new one; in the second, to try every lamp, pushing it more firmly into the socket; in the third, to remove the cover of the switch and tighten contacts. If the trouble is not found to be due to any of the above causes, you should resort to the advice given in another part of this book, under the heading of "Information on Incandescent Light Circuits," which will help you out of your difficulty.

Information on Open Circuits and Sparking Brushes.

The sparking of brushes will not be noticed if the armature brushes and brush holder are in good condition. If there is any sparking it may be taken as an indication that something is wrong, and may be due to any of the following causes: poor contact between the brushes and the commutator. See that there is no looseness about the brush holder, and that the springs exert proper pressure. The brushes should fit closely upon the commutator, and not make contact only at one corner. See that the brushes are not wedged in the holders, that the commutator is clean, and that good brushes are used. An open circuit in the arma-

ture connections of one motor will cause a heavy current to pass through the other armature, and this may produce a steady flare of the commutator. A weak magnetic field, caused by open circuit or short circuit, or wrong connections in the field coils, will also produce a steady flare, due to the heavy current. If the field circuit of a motor is not complete, owing to a broken wire, a very heavy current will pass through the armature, sufficient to blow the fuse on the car or to burn out the armature. An open circuit in the armature will produce a greenish flash, which will appear to run around the commutator; while a short circuit in an armature will be made evident either by the fuse blowing, or by a jerky motion of the car. If allowed to go on for any length of time, two bars of the commutator, about 180° apart, to which the ends of the open circuited coil are attached, will gradually burn down flat, and the insulation between them and the adjacent bars will be partially destroyed.

The marks on the commutator will serve to show which coil has the open circuit, and this should be corrected at the earliest possible moment. There are two ways of doing this, one being to replace the defective coil with a new one, the other being to put on a jumper. To do this, the canvas cap at the commutator end is removed, the two ends of the defective coil disconnected from the commutator, and an insulated wire of the same size soldered into the two bars, thus connecting them directly together. The coil itself is not disturbed, the ends merely being cut off and insulated. This will not visibly affect the running of the motor, and this jumper may be left on until it is convenient to make more complete repairs. A flat bar, or bars, will cause sparking and blackening of commutator, and should be remedied as soon as found, by smoothing down with a file, or turning the commutator off a slight cut and smoothing with fine emery cloth.

Some Questions Which You May be Called Upon to Answer.

As it is an assured fact that all Motormen running electric cars must sooner or later pass an examination before a Board of Examiners, I will now give you a synopsis of the questions you will be asked, and the answers, all of which you will find in this book. "Forewarned is forearmed." So, if you fail in the examination you will have no one to blame but yourself, for they cannot ask you anything that does not actually pertain to your car and its workings, as you are not paid to know anything not pertaining to your car.

Some of these questions require very lengthy answers, but are very simple when you learn them by heart, and by a very little study on your part there is no reason why you cannot pass an honorable examination.

You will be asked to define in part the term "short circuit," which has been sufficiently treated in this book.

You will be asked what causes electricity to heat.

There is only one proper answer to this question, and that is "resistance." Electricity must be resisted in order to cause heat.

You will be asked to explain the term "ground" or "grounded," and its causes. This has been explained in another part of this book.

You will be asked what kind of motor you are or have been running, their names, and the amount of electricity they are built for. This you will have to learn from your Superintendent or the electrician in charge, as I have no means of

knowing what particular make of motors you are running.

You will be asked in case you could not reverse your car with the reversing device, what you would do. This question has also been fully treated of previously.

You will be asked in case certain parts of your car should become disabled, what course you would pursue. This question you could answer correctly by memorizing the teachings of this book.

You will be asked to trace out the current, beginning at the trolley wire and ending with the ground wire, naming every part of your car and motor as you proceed. As I have been very careful and accurate in my explanations of the current tracing, you have no reason for not being able to answer correctly.

You will be asked what you would do in case your car becomes groundedbecause of dirty rails. Most Motormen can answer this question, but for the benefit of those who have not had experience, I will say: connect the rail with any part

of your wheel or truck, with a piece of wire or any piece of iron you may have handy, and your car will start. All that is necessary is to get a clean connection with the rail.

You may be asked what you would do in case your controlling cable should break on a car equipped with a rheostat controllor, and you were unable to use the controlling device.

The answer is, throw off one of your overheads and gather up your broken cable and tie it up so that it will not come in contact with any other working part of your car. Then pull your traveler one-third of the way around on your rheostat, and control your car with the overhead switch. Take advantage of all down grades and run by gravity, so as not to heat your rheostat any more than possible. The traveler left in one place on the rheostat for any length of time, will become red-hot, and consequently burns out the resistance.

You will be asked how you determine

how many miles per hour you are traveling. This question will be asked for various reasons. For instance, in case of an accident that would result in the Motorman's arrest, he would be called upon to state the rate of speed he was running at the time of the accident. The manner of determining the rate of speed a car is traveling, is very simple. All you have to do is to count the number of rails you pass over in twenty seconds, and it gives you the number of miles per hour.

You also have orders from your Superintendent not to run faster than a certain rate of speed over different parts of the road, therefore you should keep this rule in mind.

Other questions may be asked you, all of which you can easily answer by keeping this book constantly with you and by frequently referring to it.

Points of Interest to all.

While employed as a Motorman, I was frequently asked by passengers as to how long an incandescent lamp would last, and I presume my readers have all been asked the same question. As we all like to be able to answer such trifling questions when asked them, I think it will be well to give a little information on these points, as many of you, perhaps, have never heard how long they were supposed to last:

An incandescent lamp, when used as they are supposed to be used, that is, not overtaxed by higher voltage than they are manufactured for, will last about one thousand hours. That is considered to be the average life of a lamp, or as long as they are supposed to burn, although they will, in some cases, burn twice that

length of time. But they are not guaranteed by the manufacturer for over one thousand hours.

Another question that is quite frequently asked by the traveling public is, where does the current go to after it passes through the motors. This question is answered by stating that it returns to the generators at the power station through the ground wire that is laid along the track.

Some one else may ask you how many revolutions per minute your armature makes. Of course that must be determined by the number of miles per hour your car makes. If you have a thirty-inch wheel, and your gearing is of standard size, then your armature must make 3,379 revolutions per mile. If you wish to find out how fast the armature revolves in your car, multiply 3,379 by the number of miles per hour your car runs, and divide it by 60, and you have it. For instance, if a car runs 20 miles per hour, the armature revolves 1,126

times per minute, and as they are very heavy, you can see by this what a great strain it must be on gears and pinions when you reverse your car when running at a high rate of speed.

There is the trolley wheel also which causes a great deal of comment and argument, as to how fast it travels on its axis. Very few men running cars ever stop to think how much wear there is on this little wheel which travels on the wire over their heads. The average size of trolley wheels is about nine inches, that is in circumference, which necessitates it to revolve 2,344 times per minute; when you are running at a speed of twenty miles per hour the revolutions it must make per mile are 7,040.

While speaking of the trolley I will give you a little of my experience in regard to how I have procured the best results from a trolley. If the tension in a trolley is a trifle too weak, it will jump off the wire at nearly all overhead switches and crossings, especially if you do not cross

them very slowly; for every time the wheel strikes a little uneven place on the wire it will cause it to bound, and it seldom goes on the wire when it goes up again. On the other hand, if you have your tension too stiff, it causes unnecessary wear on the wheel, and when it does come off, unless some one has hold of the rope, it is liable to break a span wire or bend the pole, or perhaps both. My experience has been that a trolley gives best satisfaction with a tension of about fifteen pounds at the wire. That is, get a piece of iron weighing fifteen pounds, and tie it to your trolley rope. Get up on the roof of your car, place your trolley pole so that it will stand at an angle of 45 degrees, and then adjust the tension so it will just balance the weight, and then you have got a tension that will give better satisfaction than I was ever able to obtain from any other amount of tension, and I have tried them in many different ways.

That disagreeable, roaring sound which

is caused by the trolley wheel, and which causes so much annoyance to passengers can, in most all cases, be stopped by putting a little oil on the trolley wheel, as when they are allowed to run dry they will get rough and soon begin to cut the pin and bushing, which is the cause of the noise.

I speak of these little things because the man who looks after all these troubles in his car, soon gains the endorsement of his Superintendent as a good man. For if he keeps everything in this line up in good shape, he is sure to have his car running much smoother in all respects than a man who pays no attention to the working of his machinery. I am sure there is a sufficient amount of self-satisfaction in having everything work nicely to pay a man for what little extra time it takes to keep them up.

While I am allowing my pen to drift in this channel (of what may be termed novelties), I will just relate one more little trick of the trade which I have found

quite useful in a number of cases, and if you have heard it before, I beg your pardon for taking up your time with it But to those who have not heard it, it may some time help them out.

Once I was on a run that made me the last man in the house, and I caught a large load from a party. In starting on a grade I blew a fuse and found that I had no other one to replace it with. After looking around in every place for a piece of wire of some sort to use as a substitute for the fuse, I was at a loss to know what to do. All at once I thought of a way out of my trouble, and opening the car door I asked if some lady would please give me a hairpin. This I got, and putting it in for a fuse, I was enabled to take my load to its destination.

Again, should the carbons or brushes in your motor get to making a shrill, screeching noise, you can in most cases stop that annoyance by removing the brushes and rubbing a little lubricant of some kind on them. I would not recom-

mend you to use ordinary oil as it will gum on your brushes and commutator, and cause them to flash. But if you will go to a drug store and purchase five cents worth of vaseline or paraffin gum and use it, it will stop this disagreeable noise, and will not gum up on your commutator. But never put on but just a little. This is also a good remedy for a controller of most any type that works stiff, as they do often, and thereby making them disagreeable to handle. Just put a little of this lubricant on that portion of the controller which makes the contact, and you will find that they will work much freer.

General Electric 800 Railway Motor.

The General Electric 800 is a four-pole Motor, having two salient and two consequent poles. The pole pieces are cast as part of the frame, and the field coils are secured in place around them by means of removable flanges. The field coils have been designed with special attention to thorough insulation.

The utmost care is taken in the selection of the materials, tests being made with samples of all wire, paper, cloth and tape used in their manufacture. Equal precaution is maintained in the winding of the coils and in the application of the insulating material. The field winding consists of asbestos covered wire wound on special formers without any spool or shell. After removal from the former, the coil is first wrapped with canvas strips and then immersed success-

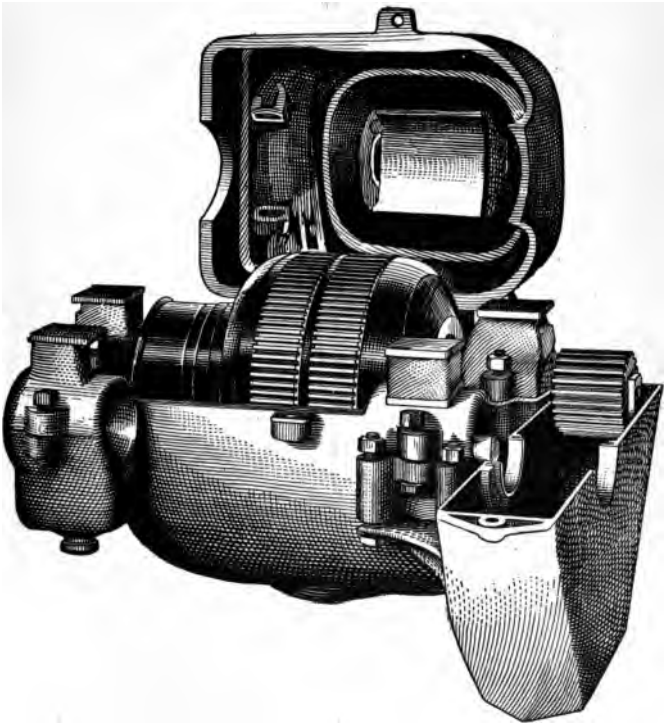
ively in oil and japan, and afterwards baked. This construction results in a so-called mumified coil, which is impervious to moisture, efficiently protected from mechanical injury, and capable of withstanding such excessive temperatures as may result from overloading.

It is therefore well fitted to render long service under the exacting conditions imposed in street railway work. The armature is of the slotted or ironclad type, with Eickemeyer winding. The disks forming the core are first punched from thoroughly annealed iron, then again annealed and japanned. The second annealing after punching ensures a low core loss by removing the hardening effect of the punching. The disks are then built up on the shaft, after which the slots in the core are carefully prepared for the insertion of the Armature coil.

The invention of the Eickemeyer Machine wound armature coil marked an epoch in the art of railway motor con-

struction, for it made possible a design and method of manufacture whereby a coil of general excellence, electrically and mechanically was produced and which had the following principal characteristics: Durability, interchangeability, high insulation, imperviousness to moisture, facility for repairs and capability of withstanding excessive heating.

The General Electric Company's Machines have become so ironclad and durable that most Street Car Companies have adopted them for use on their respective roads, and I take pleasure in giving Motormen all the information possible in connection with them. And any Motorman who cares to study a little along with his practice can in a very short time be able to master these most popular machines as there is nothing so complicated about them but what any man of ordinary intelligence can understand by memorizing the teachings of this little book.



General Electric 800 Railway Motor.

The following are some of the principal things a Motorman should thoroughly understand: Sparking at the commutator, this is caused by many things. The Mechanical causes are: First, looseness of commutator; Second, untrue surface of the same; Third, loose brush holder; also brush stuck in holder and improper pressure on brush, etc. The Electrical causes are: Broken wires or connection in the armature, also excessive current in armature, weak field or misplaced rocker arms. If the current in the armature is too large in proportion to the field magnetism, there will be a distortion or twisting of the direction of the magnetism from the pole pieces, caused by the magnetism of the armature itself, and the result will be that the non-sparking position of brushes is changed, and the brushes being in their normal position will spark. Any spark caused by this or by misplaced rocker arm will be a steady flare and will not be worse on one part of the

commutator than another. If it comes from field trouble it will vary with the position of the switch. If the contact surfaces of the brushes are not on opposite bars of the commutator, the machine will spark. If the brush-holders are in order the face of the same should be about ⅛ inch from the commutator. If the commutator flashes on certain bars, or if, when running fast, points of flame seem to dart out from the brush and extend part or all way round the commutator, the cause is generally a broken wire or connection in the Armature. An armature with a broken wire in it will run without jerks, but with less force than a good one. It should never be allowed so to run as the sparking burns the bars of the commutator where the break is. If the broken wire in an armature cannot be readily got at to repair, the commutator bars on either side of the break should be soldered together, and the Armature will practically be as good as new. One coil will be cut out;

but this will be inappreciable. Three or four or more coils might be cut out in case of need, and the armature would still be serviceable. The same thing applies to grounded or crossed armatures where only one or two coils are involved. The coils can be cut out and properly separated from the commutator, and the armature may be good for service again in a few hours. Field magnets are liable to be injured by overheat or by mechanical causes, and in some cases, might short circuit or ground when cool, but these cases will be very rare. Trouble with the fields will be shown by irregularities of speed, and by sparking at the Commutator as described. No motor should be run unless its field is in good condition. All that has been said about the causes and effects of different troubles with fields, may be better understood by a careful study of the different connections of the motor and switches, a print of which will be found in this book.

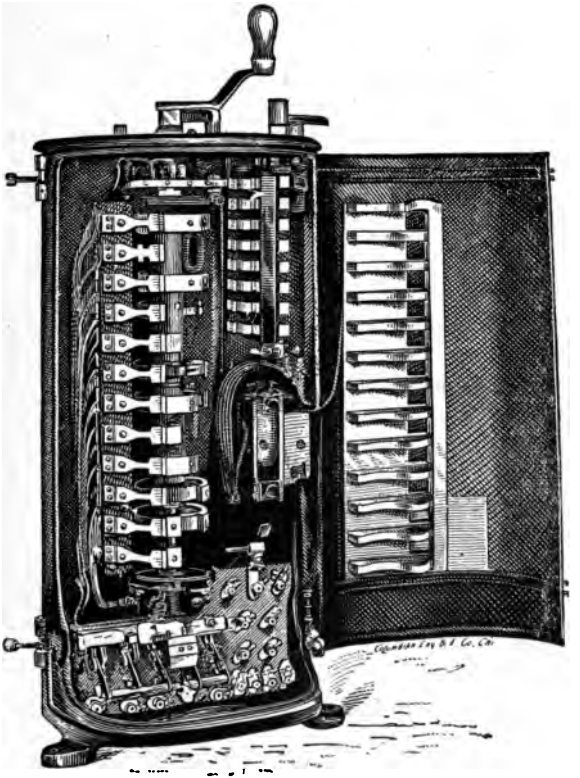
Every man who works on or about

motors should make himself familiar with everything in connection with them.

In another part of this book under the heading of "How to Locate Trouble in a Car While on the Road" will clear up any trouble you may have, and as a motor man is paid for what he knows about motors he should endeavor to increase his salary by learning his machine thoroughly.

General Electric Company's Series Parallel Controller.

The purpose of an Electric Street Car Controller is to start, to stop and to regulate the speed of a car in the most convenient and the most economical manner. A controller is put in the care of a man knowing little or nothing of the theory or practice of electricity or of mechanics. The mechanism is in almost continuous movement, either starting, stopping or changing the speed. Currents at 500 volts must be broken thousands of times each day between the controller contacts, and when in operation the apparatus is subjected continuously to mechanical shocks and electrical stresses. The first commerical series parallel controller with magnetic blow-out was the Type J., March, 1892. The form E.,

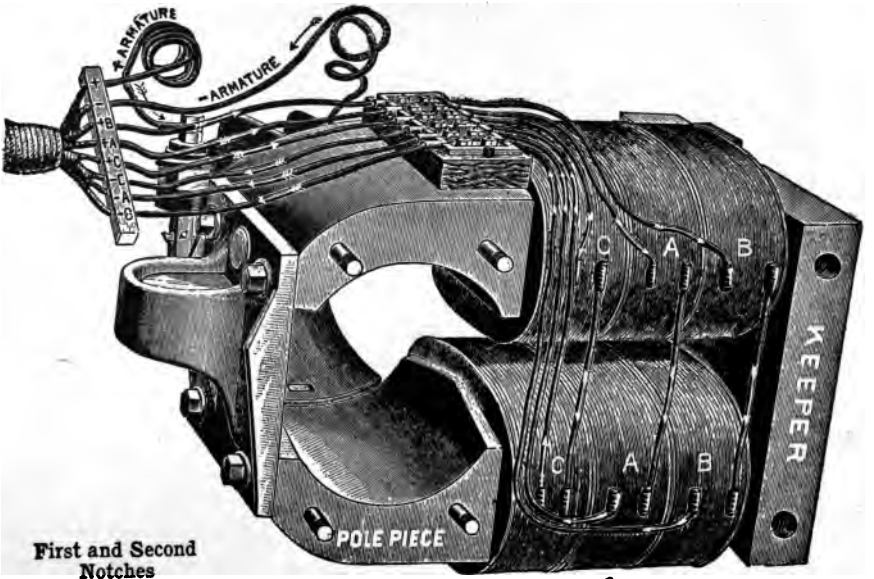


"K" Type of Series Parallel Controller.

September, 1892, came next and was the beginning of the cylinder controller. This had an external reversing switch. The form K., February, 1893, combines both controller and switch in one case and has remained for several years unchanged, except in details.

The various controllers which are known as K 2, K 10, etc., are simply modifications of the K to fit them to larger or differently wound motors. No new principles are introduced because the K was in its original form, a practically perfect controller. This being the latest type of controller and one most in use. I have taken great pains to make it so plain and complete that every motorman can, by referring to the accompanying illustrations, post himself on every detail in connection with this most popular controller.

"R" Type of Rheostatic Controller.

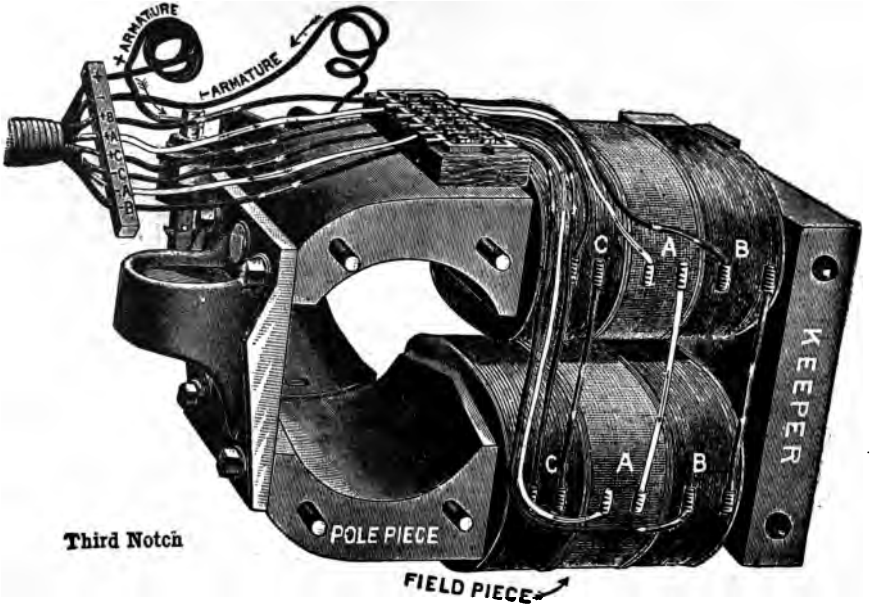

+ARMATURE
-ARMATURE
TERMINALS
C
A
B
KEEPER
C
A
B
POLE PIECE
First and Second Notches
FIELD PIECE

Description First and Second Notches.

The annexed cut represents by arrows the flow of the current from the controlling switch through the various wires and field coils back to the switch.

When the switch handle indicator points to the first and second notches the current flows through the three field coils in series.

The current leaving the switch flows through + B wire, through B coils, returns through — B wire to the switch, thence through + A wire and both A coils, returning through — A wire to the switch, thence through + C wire and both C coils, returning through — C wire to the switch, thence through + Armature wire, through brushes at one side of the commutator to the Armature, returning through the brushes at opposite side of commutator, thence through — Armature wire to the switch, thence through the cut-out box to the ground.

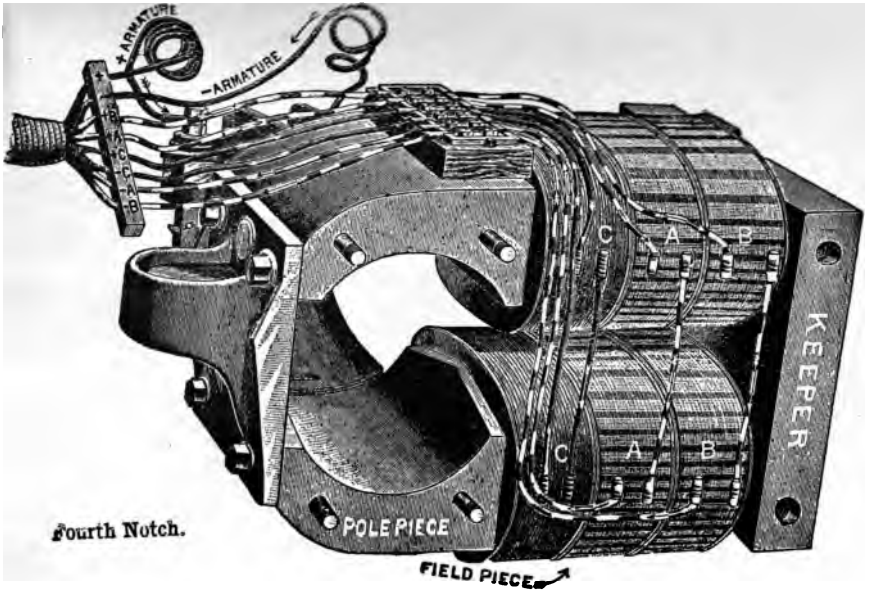


Third Notch

Description Third Notch.

With the switch handle indicator on the third notch the current flows through + B wire, through both B coils and returns through B wire from where it enters + C and flows through both C field coils, returning through — C wire to the switch, from where it flows through + Armature wire, through the brushes at opposite side of commutator to — Armature wire, back to the switch, thence through the cut-out box to the ground.

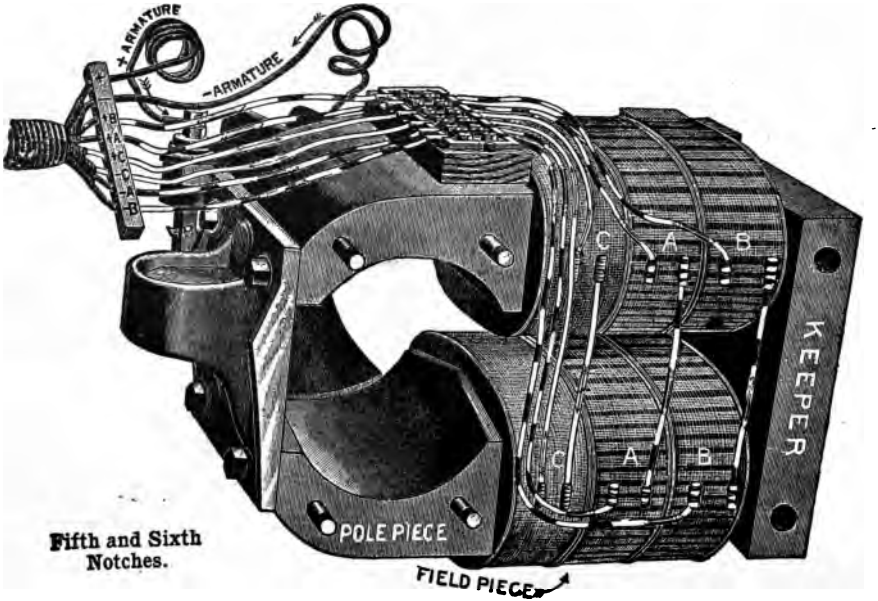
It will be noticed that when the switch handle indicator is on the third notch that the A field coil is entirely cut out.



Fourth Notch.

Description Fourth Notch.

With the switch handle indicator on the fourth notch the current flows through + A and + B in multiple with each other, returning through — B and — A simultaneously back to the switch and thence through + C through C field coils, returning through — C to the switch, thence through + Armature and through the brushes to the Armature, thence through — Armature wire from brushes on opposite side of the commutator to controlling switch, to the cut-out box and thence to the ground.



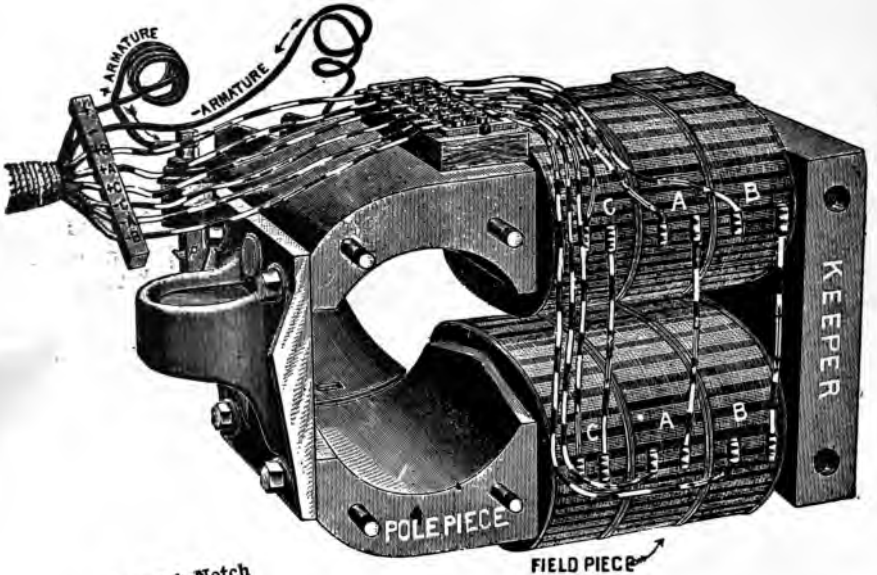
Fifth and Sixth Notches.

Description Fifth and Sixth Notches

The fifth and sixth notches show alike, the current flows through + B and + A, through B and A field coils in multiple, thence through — B and — A simultaneously to controlling switch, from whence it flows through + Armature wire to the Armature at the brushes, thence through — Armature wire from brushes on opposite side of commutator back to the controlling switch to the cut-out box and thence to the ground.

It will be noticed by this cut that the C coil is entirely cut out, and motormen are requested to use the fifth and sixth notches as little as possible, and never for any distance on up grades.

With the switch handle on the seventh notch, the current flows through + B, + A and + C simultaneously through all



Seventh Notch

the field coils in multiple, thence through — B, — A and — C wires, back to the switch, thence through + Armature wire to Armature at the brushes, returning through the brushes at opposite side of commutator through — Armature back to the controlling switch, thence through the cut-out box to the ground.

It will be noticed by the above cut that the current flowing equally through all the field coils simultaneously, that this is the best notch for heavy work.

Note, that in the description of the course of the current in the above cases, the current after going through the different combinations of field coils, is described as going in at + Armature and coming out at — Armature. This is true only of one motor. With the other motor the course through the field coils is the same but the current goes in at — Armature and comes out at + Armature. This is owing to the fact that the two motors are hung in a reversed position with respect to each other, and this

crossing of the Armature wires causes both car axles to be revolved in the same direction.

NOTE —In repairing field coils it is essential that the coils be placed on the cores in the order B, A, C, counting from the keeper. The new coils sent out by the Edison Company are all alike and must not be placed on field cores with either A or C coils.

Methods for the Government of Motors.

The amount of current which passes through one of the motors at any time (the condition of the line being equal) is governed by two things: First, the speed of the armature. Second, the position of the switch. If the wheels of the car could not move at all the motor would soon burn out if the current was left on, even on the first notch of the switch. And on the other notches it would burn out much faster. When the armature revolves it generates a counter electromotive force and the faster it turns the greater this force and the less currents will pass. This one reason is why care must be taken in handling cars off the track, or where the wheels cannot turn freely. This is not the only reason however. Every time the switch is moved or thrown on or off, changes in the mag-

netism of the iron of the motor occur. Now these changes in magnetism induce electro-motive forces in the wire of the motors entirely independent of the electro-motive force derived from the dynamo. These forces only last an instant while the current is starting or stopping and their tension depends upon the volume of the current made or broken. Thus, when the switch is thrown on or off when the car is stuck so the wheels cannot turn, these inductive effects are very heavy and may subject the insulation of the motor to thousands of volts for an instant. The same may be said of reversing the motor or moving the switch or shutting it off before the car has gained proper headway. In all ordinary service these inductive effects are inconsiderable and their force is largely expended in inducing harmless currents in the copper spools of the magnet.

In regular service of cars, with trail cars or without, there will be no trouble with motors being overloaded, provided

all the connections of the car are right. The motors can get very hot without danger but are less liable to trouble when they are cool. Any broken connection on a motor or any other electrical trouble will immediately upset the balance between the two motors and the result will be that certain parts of one or both will heat, the commutator will spark and if the trouble is not attended to, and the car left running, serious loss is sure to result.

Hardly any electrical defect can exist on a car without making itself known to the motorman. The speed will be affected on one or more notches of the switch, the brushes and switch will flash, and the car will show by its sound that both motors are not working together. The quickest way to locate trouble is as follows: First, does it appear equally from both switches? If not, it is in one of them. If not in the switches, cut out one of the motors and try the other. If it works all right on all positions of the

switch, that motor is good; then try the other. The condition of a motor working alone can be told by the action of the car, and if there is any trouble its position can be learned. In the ordinary stopping of a car a motorman should never bring his car up with a jerk, but should ease up on his brake in time to take up the loss of motion in the gearing so as to enable his armatures to make a smooth start, also save the wheels from becoming flat.

Westinghouse S. P. Controller.

The pointer in ordinary running should rest on the third notch for slow speed, and should be turned against the stop, (or as far as it will go) for full speed.

Notches 1, 2, 4 and 5 are to be used only in starting, and are not to be used continuously.

The use of notches 1, 2, 4 and 5 continuously will cause damage to the apparatus by burning out the diverter.

The reversing switch is situated in the controller case, and is operated by a lever which goes through a slot under and to the right of the controller top. As there is no arrangement on the controller to prevent the reversing lever from being thrown while the current is on, motormen must be extremely careful and not change the position of the lever, unless the controlling lever is on the off position. To reverse the motors while the current is on will result in the destruction of the reverse switch, and perhaps the entire controller.

The fuse box is located at one end of the car on the outside, and is fastened on the platform timber. This fuse box is provided with a removable fuse block, to which is attached the fuse consisting of a piece of No. 12 copper wire. To renew a fuse the fuse block must be removed with the fingers and a new fuse inserted into the binding posts and the block re-placed in the box.

When both motors are in working

order, the two plugs situated on the inside of the controller case will enter both double sockets. When it is necessary to cut out Motor No. 1, (motor nearest fuse box), remove the plug from socket marked No. 1, and to cut out Motor No. 2, (motor farthest from fuse box), remove the plug from socket marked No. 2. When you have one or the other motor cut out, the motor in circuit will refuse to start until the pointer has reached the fourth notch. Move the pointer from the fourth notch as the car accelerates.

There are six points or notches to the Westinghouse S. P. Controller, each of which gives a corresponding speed, and all of which are passed over by a single revolution of the handle. The reversing is done with a separate switch, the handle of which projects from the right side of the stand. The controller is operated entirely by feeling.

The first notch throws the whole resistance and the two motors in series;

the second notch cuts out half the resistance; the third notch the whole resistance; the fourth notch throws both motors in parallel with one another and one in series with the whole resistance; the fifth notch reduces the resistance one-half; and the sixth notch throws out all the resistance.

For the best results the following should be borne in mind:

The first two points are starting notches, the third a good slow speed running notch; the fourth and fifth are intended for getting up high speed, and the sixth notch for the most rapid travel and best efficiency. The reversing switch has three notches. The central position cuts off all current from the motors, and is the only one in which the handle may be removed from the stand. The other two notches control the direction of the movement of the car. The handle must be thrown forward or backward according as the car is to move ahead or back; i. e., throw the handle in

the direction the car is to move. A single throw of the reversing switch reverses the direction of the current in the armature, and such rude treatment should never be resorted to except in case of emergency, for it causes a severe strain on the motors. If the field coils or armature of either of your motors get too h t you should report it, and you should particularly notice if any one coil or part is hotter than usual, as this will generally indicate something wrong.

You should notice particularly if your car takes the proper speed on all points of the switch. You should watch the overhead line, and if you are near when any wire breaks down, you should endeavor to tie it up to the nearest pole so the line will not be grounded, after which you should telephone to the power house that it is O. K.

If from any cause the current is shut off from the line causing a general stoppage of cars, care must be taken to prevent all cars from starting at the same

time or immediately after the current is turned on. After finding out that you have no current do not keep trying your controller to ascertain if your car will start but go immediately and turn on your lights, and if they don't burn you have no current on the wire. Do not start your car the moment your lights begin to glow but wait until they burn bright, then start and run slowly.

Economy Is Wealth.

Some motormen do not know the difference between a single reduction and a double reduction motor. For the benefit of those who do not know, I offer the following explanation.

A single reduction machine has but one pinion on the armature, and one large gear on the axle. While a double reduction machine has a pinion on each end of the armature and two gears on the axle. For speed and continuous service the single reduction gives the most sat-

isfactory results and consequently are mostly in use at this writing.

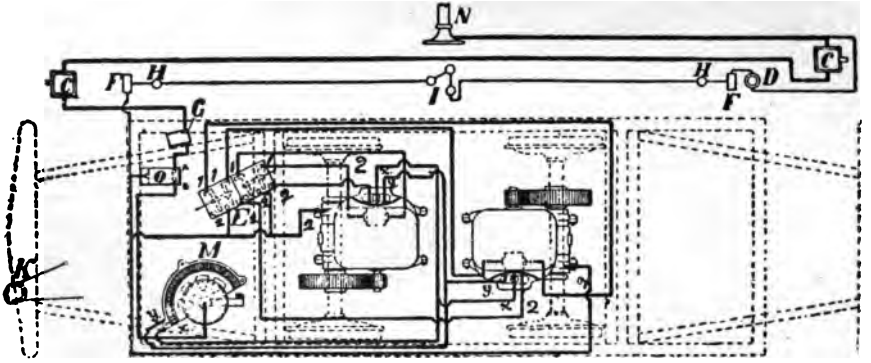
A great many motormen running cars at present, if asked what kind of machine they were handling, single or double reduction would not be able to answer correctly, for the reason that they have never had an opportunity to learn the difference between the two.

There is another point I wish to speak of that is generally understood by most motormen but seldom practiced, and that is economical running or the saving of electricity. A motorman can, if he has the inclination, take advantage of all down grades on his run and save his company many dollars in a month's service. There is no line with a time card so figured up that will necessitate the power being used continuously over the entire route. There are lines now in operation that call motormen to account for the excessive use of current.

Some electric roads I have had the pleasure to visit have adopted the method

of placing a recording Watt meter on each of their cars which registers the amount of current used by each car, and they know about what amount of current is necessary with proper care on the part of the motorman to make the days' run, and if the motorman in not economical his empl yer has the means of knowing it, and consequently his services are soon dispensed with.

Never go back on the ship that carries you over, but use every advantage at your disposal to save the company who furnishes you with the means of making a living for yourself and family. Save all you can for them and it will save you your position longer than it would otherwise.



C R. R. Motor Switch.
D 15 Light Branch Switch.
E Reversing Switch.
F 10-35 Light Cut-out Box.
G R. R. Motor Cut-out Box.
H Pilot Lamp.
I Three Lamp Cluster.
O Lightning Arrester.
M Rheostat or Resistance Coils.
N Trolley Stand.
Y End Wire.
X Loop Wire.
1 Brush Wires.
2 Dead Ground Wires.

Conclusion.

In writing this book it has been the author's intention, as has been previously mentioned, to confine himself exclusively to the working of street R. R. motors and while I have not endeavored to explain each different type of motor (of which their are a great many) separately, still I think I have given you just such information as you need, and such as you have been searching for in vain.

This book has been written so as to be utterly devoid of all theoretical or scientific explanations, as it is not intended for that class of men. It is gotten up for Motormen only, written in Motormen's phrases, and confined to the principles of these most popular machines, and as the fundamental principles of all street R. R.

motors are controlled by the same rules, I think I am giving you something in this book that will prove beneficial to you no matter what type of motor you may be handling.

And as a conclusion I would say that, if you will commit the contents of this little book to memory, and allow yourselves to be governed by its teachings, that you will, in the majority of cases, meet with success in your attempts to locate and overcome little troubles such as most frequently present themselves to you. And in connection with these teachings, keep yourselves familiar at all times with the rules and orders of your superintendent (which are usually posted on the bulletin board), and there is little doubt in my mind but what you will be able to gain the endorsement of any superintendent in whose employment you may be, and at the same time you need not fear the consequences of any examination which you may be subjected to as to your ability as a Motorman.

In writing this edition it is the author's intention to make it indispensable to every man running an electric car; to make his duty more of a pleasure than a task.

As the author has served as an employee of several different companies, and in all capacities, he feels competent, and at the same time it is his duty to communicate to street railway employees the following method of behavior and obedience to their employer.

Speaking from experience, if you follow these suggestions, you cannot fail to hold your position.

It is true that companies owning and operating electric railways are becoming very strict, and consequently keep their employees in a state of constant fear of being discharged, which makes their duty doubly arduous.

Every time an obnoxious order is posted upon the bulletin board, or an order that will seemingly make their duties more unpleasant, there is a general kick among

the men, and knowing that they have to submit or step down and out, puts a roving disposition into their heads, thinking they can find another road that is not so strict. But this is a mistake, for you will find them all the same.

Nine-tenths of all the men running on cars are always looking for and trying to locate the superintendent or his assistant, and I don't know of a case where any good came of this, for if you know the exact location of these distinguished gentlemen, you will commit yourself a thousand times to a spotter, thinking you are O. K. The ends of every street car line are seemingly left unguarded, and are, so far as the superintendent is concerned. But don't forget that he has the means of knowing every move you make, while you think you are safe. Therefore, if you wish to retain your position, or even if you do not wish to retain it, you had better adhere to the following rules, and you can always obtain another position in case you wish a change. Remember that when a com-

pany employs you, it does not only employ you to run its cars, but to run them according to its plans and dictation, and knowing that you have to conform to its rules and regulations or leave, I will say go to the bulletin board and familiarize yourself perfectly with all rules and orders, and when you start out of the car house with your car, you do so with the knowledge that you are going out to work for your family or yourself, at so much an hour, or a monthly salary, as the case may be. Go out resolved to live up to every order and rule laid down by the company. Lay all ideas and notions of your own of running a car aside, and adhere strictly to their way, and the way they pay you for. By so doing you have dispensed with all fear of being discharged for disobedience of orders, for they certainly cannot discharge you for obeying their own orders.

If you discharge your duties according to this doctrine, you can face the Su-

perintendent at any time without fear of having incurred his displeasure.

If you should in the discharge of your duties commit yourself, or do something that you feel that you are to blame for, at your first opportunity go to the Superintendent and tell him the exact truth of the matter, or trouble in question, and if there is a spark of manhood in him he will set you right by requesting you to be careful in the future.

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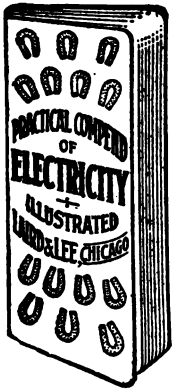

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